Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

PUMP CALIBRATION PROCEDURES FOR DUST SAMPLING INSTRUMENTS USED AT CBCRL

D.A. Young
Cape Breton Coal Research Laboratory

July 1987

35 pp

COAL RESEARCH LABORATORIES
DIVISION REPORT CRL 87-74(TR)

88-02137/

PUMP CALIBRATION PROCEDURES FOR DUST SAMPLING INSTRUMENTS USED AT CBCRL

by

D.A. Young*

ABSTRACT

This report describes the calibration procedures used at the Cape Breton Coal Research Laboratory to maintain airflows in the pumps of respirable dust sampling systems. It also compares the performance of the pumping systems over a series of respirable dust surveys.

---

*Field and Laboratory Technologist, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney.

MÉTHODES D'ÉTALONNAGE POUR LES POMPES DES APPAREILS D'ÉCHANTILLONNAGE DE POUSSIÈRES INHALABLES UTILISÉS AU LRCCB

par

D.A. Young*

RÉSUMÉ

Dans le présent rapport, l'auteur décrit les méthodes d'échantillonnage utilisées au Laboratoire de recherche sur le charbon du Cap-Breton dans le but de maintenir l'écoulement de l'air dans les pompes du système d'échantillonnage des poussières inhalables. Il y compare de plus le rendement des systèmes de pompage obtenu au cours d'une série d'études sur les poussières inhalables.

---

*Technologue de laboratoire et de recherche sur le terrain, Laboratoire de recherche sur le charbon du Cap-Breton, LRC, CANMET, Énergie, Mines et Ressources Canada, Sydney.

CONTENTS

	Page
ABSTRACT	1
RESUME	iii
INTRODUCTION	1
CALIBRATION PROCEDURES AND EQUIPMENT	1
Soap Bubble Flowmeter (SBF)	1
Preparation of A Soap Bubble Flowmeter	4
Measuring Airflow with a Soap Bubble Flowmeter	4
Other Standard Flow Measuring Devices	4
Casella Type 113A	4
Preparation of the Casella Type 113A	6
Casella Type 113A Calibration	6
Comments	9
SIMSLIN II	9
SIMSLIN II Preparation and Flow Check	11
DuPont 2500A and Gilian HFS-113A	15
'Personal' Pump Preparation and Flow Check	15
Comments	15
PUMP PERFORMANCE DISCUSSION	16
Comparison of Pump Flow Variations (Using Two DuPont 2500A Pumps)	16
Comparison of Cumulative Flow Failures of The DuPont 2500A, Gilian HFS-113A and Casella Type 113A Pumping Systems	20
CONCLUSION	21
ACKNOWLEDGEMENTS	22
REFERENCES	22
APPENDIX A	24

TABLES

No.		Page
1.	Equipment listing (general)	2
2.	Equipment listing (soap bubble flowmeter)	7

No.		Page
3.	Typical data presentation	17
4.	Comparison of pump flow variations	18
5.	A list of surveys and number of pumps used during each test. Below column 2, 3 and 4 is the percent of flow failures, "FF"	19

FIGURES

No.		Page
1.	Soap bubble flowmeter (SBF)	3
2.	"SBF" and personal sampler	5
3.	Casella Type 113A flow check	8
4.	Casella Type 113A pressure drop check	10
5.	SIMSLIN II control panel	12
6.	SIMSLIN II continuous dust monitor	13
7.	SIMSLIN II flow check	14

INTRODUCTION

The long-term goal of the respirable dust program at CBCRL is to reduce coal miners' exposure to airborne respirable dust. In order to achieve this, dust monitoring equipment which provides accurate and precise results must be used.

Dust monitoring equipment consists of the following components: a) dust separating device, b) dust collection media and c) pumping system. Dust separating devices used at the CBCRL are horizontal elutriators, cyclones and impactors. Dust collection media consists of various filters and substrates used in a variety of samplers (6). Pumping systems provide a constant flow and are battery operated and electronically controlled.

This report looks at the various pumping systems and the calibration procedures used at CBCRL to maintain airflows to dust collection devices. A complete list of pumps used at CBCRL can be seen in Table 1.

The second part of this report deals with data presentation and interpretation of general pump performance. The data used in this section was obtained from thirty dust surveys undertaken at two underground coal mines. Deviations of two selected DuPont 2500A pumps were used to explain pump performance and 'flow failure' occurrences. Flow failure is defined as those flows that did not fall within the flow range specifications as set by the manufacturer and user following the sampling period.

CALIBRATION PROCEDURES AND EQUIPMENT

SOAP BUBBLE FLOWMETER (SBF)

The soap bubble flowmeter is a primary standard device used to measure air and/or gas flows. It consists of an elongated glass cylinder graduated for specific volumes. It also contains an open or closed soap film injection port at the bottom end and a closed top side containing a .5 cm (ID) spout for tube connection (Figure 1).

Table 1 - Equipment listing (general)

NAME	MODEL	QUANTITY
SIMSLIN II	Rotheroe & Mitchell Continuous Dust Monitor	1
Casella Gravimetric Sampler	Type 113A, Four-channel Elutriator	4
DuPont	P-2500A	12
Gilian	HFS-113A	9
	Charging Systems	
Rotheroe Mitchel	bc7-115V/60 Hz	1
Gilian	HFATR-5-115V/60 Hz	2
DuPont	P-2500A Series Charger	4
Carlton Instruments	Model/c-1308-T12981	1

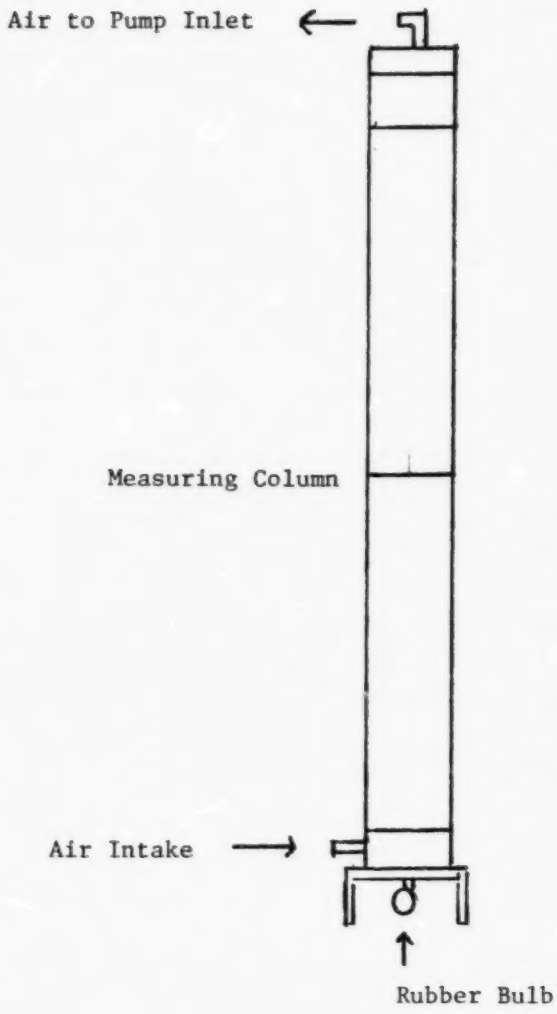


Figure 1 - Soap bubble flowmeter (SBF)

PREPARATION OF A SOAP BUBBLE FLOWMETER

This procedure requires the following equipment: a 1 litre soap bubble flowmeter, stop watch and a length of .5 cm (ID) tubing:

1) Locate air inlet spout at bottom of SBF (don't remove rubber bulb).
2) Add soap solution into bulb via the air intake using a small dropping bottle. Squeeze bulb to displace air and bring the level of solution just below the inlet spout.
3) Wet the inside of the SBF by inverting and rotating the column. This will prevent the soap bubble from bursting during flow measurements.

MEASURING AIRFLOW WITH A SOAP BUBBLE FLOWMETER

1) Connect the air intake of any pumping system to the top side of a SBF. Turn pump on (Figure 2).
2) Squeeze the rubber bulb forcing the liquid above the bottom of the inlet. Squeeze for an instant and this will result in a soap film.
3) Measure the time it takes for the film to travel between two set lines, e.g. 0 to 1000 mls.
4) Repeat step 3 until six consistent results are obtained. This will provide a statistically valid number of data (4).
5) If the SBF is of a 1 litre capacity, then calculate the flow rate by dividing 60 by the average time of the trials in seconds giving a flow rate in l/min.

OTHER STANDARD FLOW MEASURING DEVICES

It should be mentioned that a calibrated wet test meter can be used as an alternate method for measuring flow with the advantage of measuring air quantities over an extended period of time. There are also other automated devices available such as electronically controlled soap bubble flowmeters, mass flowmeters, etc. However, the SBF is a primary standard flow measuring device and is used throughout this report.

CASELLA TYPE 113A

The Casella Type 113A is a self-powered gravimetric respirable dust measuring instrument. It consists of a four-channel elutriator designed to

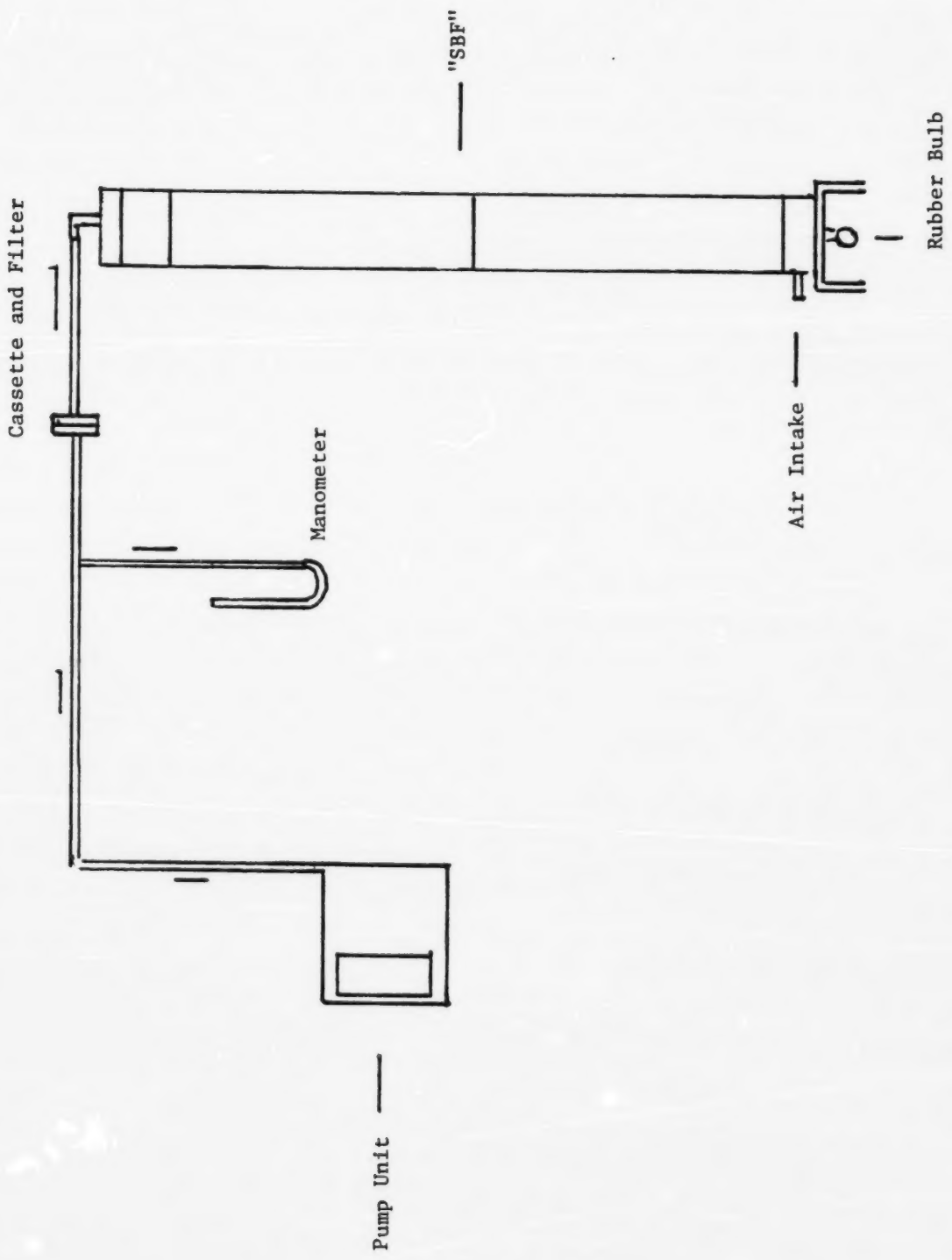


Figure 2 - "SBF" and personal sampler

separate the respirable dust from the non-respirable dust. The separating characterisitcs rely on a sample airflow rate of 2.5 ± .1 l/min. The flow rate is dependent on the motor speed and the length of the piston stroke (they are interdependent). The Casella Type 113A is the standard reference sampler used at CBCRL for which all the other sampling systems are corrected to.

PREPARATION OF THE CASELLA TYPE 113A

1) Carefully vacuum the sampler inlet and filter assembly. Remove the sampler from its casing and horizontally suspend the unit from the two rings located on its handle.
2) Install a filter and charged battery into the instrument. Turn the pump on and note the position of the rotameter for flow indication. It should indicate 2.5 l/min.
3) Pinch the tubing leading from the filter assembly to the pump. The pump should stop or nearly stop indicating that the inlet valve is functioning properly.
4) Squeeze the tubing from the exhaust valve to the flow smoother. The pump should stop or nearly stop indicating that the outlet valve is functioning properly.
5) Remove the baffling plate from the horizontal elutriator and block the inlet off. The pump should stop or nearly stop indicating no leaks in the elutriator.
6) Set the counter to zero and run the pump for 24 minutes. The final counter reading should read 59 to 61.

CASELLA TYPE 113A CALIBRATION

The following equipment is required: SBF apparatus, a strobe light for measuring motor speed, a water manometer for measuring pressure drop and a multimeter to measure pump voltages and milliamperes (Table 2):

1) Connect the Casella to a water manometer and to the SBF (Figure 3).
2) Start the pump and record the pressure drop on the manometer. It should be in the 0 to 1.3 cm range.
3) Measure the operating electric current with a multimeter. It should not exceed 50 mA.

Table 2 - Equipment listing (soap bubble flowmeter)

NAME	TYPE	QUANTITY
Soal Bubble Flowmeter	SKC	1
Stop Watch	Any type (.1 sec accuracy)	1
Wet Test Meter	QCA/Precision Scientific	1
Manometer	Gallenhamp	1
Cole Palmer Digital Multimeter	Me-530	1
Thermometer		1
Barometer	Aneuroid	1
Cole Palmer	Digitstrobe	1

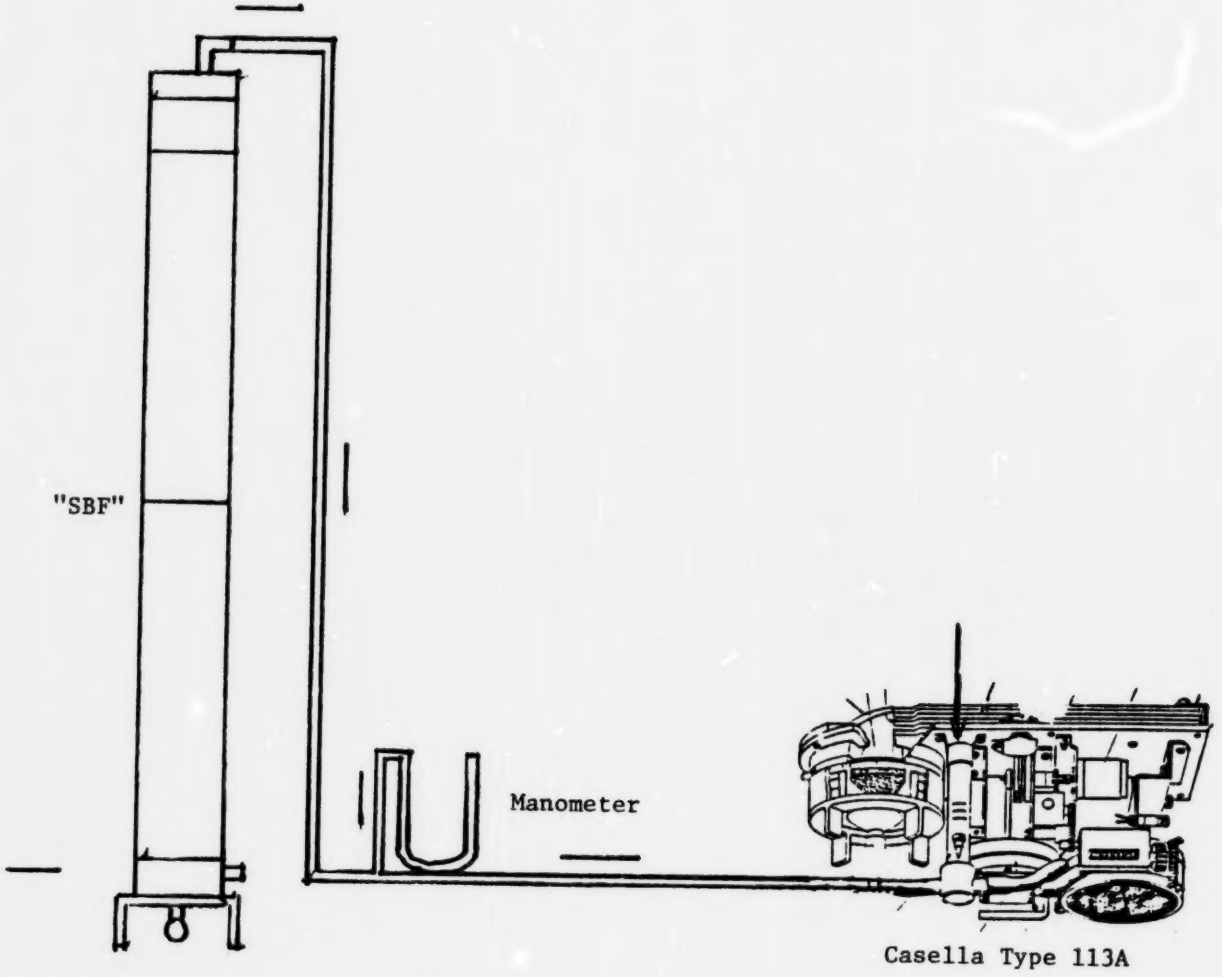


Figure 3 - Casella Type 113A flow check

4) Check the position of the rotameter, it should be in the 2.4 to 2.6 l/min range.
5) Check the motor speed, it should be 1800 ± 30 rpm. If the speed is outside this range, then adjust the voltage regulator to bring the rpms within range (check the Casella operating manual for more details (1).
6) If the flow is outside the 2.4 to 2.6 range, then adjust the piston stroke length to bring the rotameter into range. Repeat steps 3, 4 and 5 as piston stroke length and motor speed are interdependent. (check the Casella operating manual for more details on adjusting stroke length)(1).
7) Measure the flow by following the SBF procedure.
8) Disconnect the SBF apparatus and connect the Casella to the manometer (Figure 4). Record the pressure drop on the manometer and the position of the rotameter. If the pressure drop is outside the range of ± .5 cm of that measured in step 2, then repeat steps 1 and 2. If the pressure drop does not remain in the same range, then repeat steps 3 to 7.
9) The position of the rotameter may vary slightly. If it falls outside the 2.5 ± .1 l/min range, then repeat steps 1 to 7.
10) Reset the counter to zero and run the pump for 24 minutes. The final counter reading should be in the 59 to 61 range. If this range is not attained, then repeat steps 1 to 10 again.

COMMENTS

The pressure drop across the elutriator may vary from filter to filter; therefore, it should be checked for each survey. The pressure drop across the SBF apparatus, manometer and tubing should be relatively constant; therefore, tubing length which provides the proper pressure drop should be determined and its length kept constant.

SIMSLIN II

The SIMSLIN II is a continuous dust monitoring system designed to measure and electronically store respirable dust concentrations. It contains a laser optical system for displaying instantaneous dust levels plus a dust collection device. The unit employs a one-channel horizontal elutriator

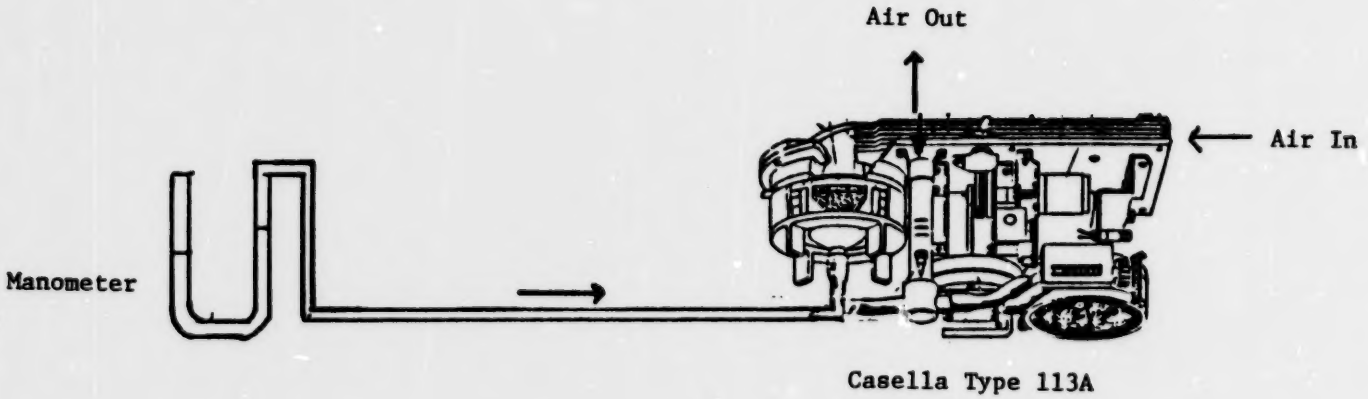


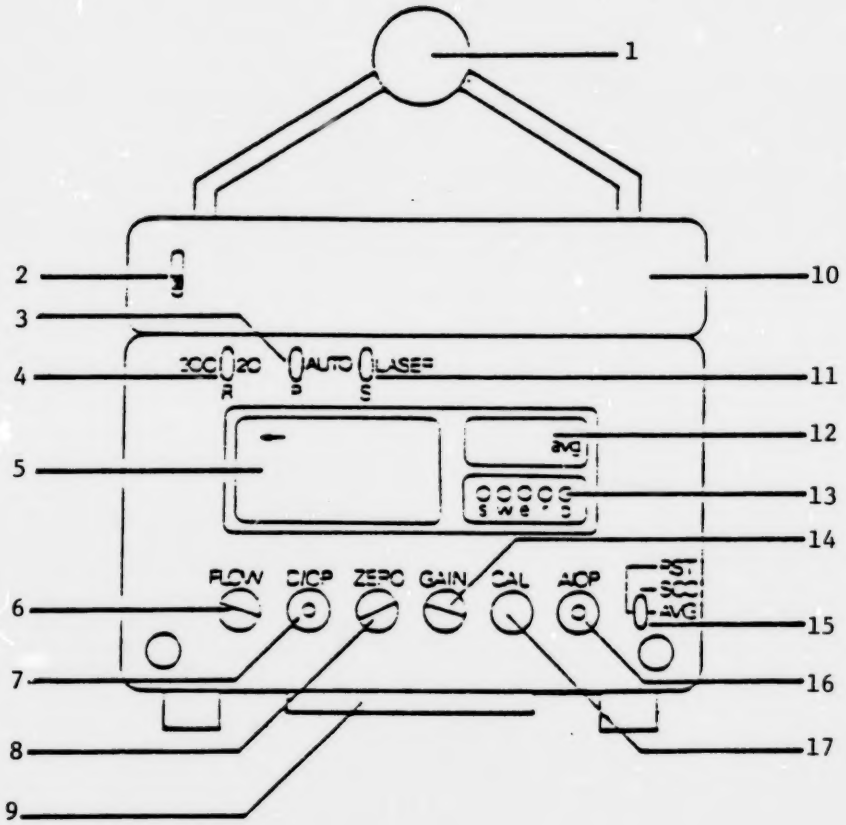
Figure 4 - Casella Type 113A pressure drop check

requiring a sample airflow of .625 1/min that is provided by a vane controlled internal pump. The calibration and setting of airflows is provided in the operating manual. The intent of the following procedure is to check the set airflow and not to calibrate or set operating parameters for the unit (Figure 6).

SIMSLIN II PREPARATION AND FLOW CHECK

The following equipment is required: the SBF apparatus and a 5.5 cm rubber stopper with a .8 cm (ID) bored hole containing a plastic connector with a .5 cm (ID):

1) Carefully vacuum the sampler and its elutriator and sit it horizontally on a table. If not level, the rotameter tends to stick or rub against the side of the glass enclosures resulting in erroneous flow measurements.
2) Set the flow to .625 1/min by following the setting up procedure in the SIMSLIN operating manual (5). This flow can be adjusted by turning the set screw on the instrument (Figure 5) (course flow is factory set).
3) Disconnect the elutriator by removing the three hex screws holding the elutriator to the top of the instrument. This exposes the cavity which is the main air intake. Clean away any loose dust being very careful not to contaminate the cavity.
4) Cover the cavity with a 5.5 cm diameter rubber stopper and clamp it into place to provide an airtight seal (Figure 7).
5) Connect the SIMSLIN II to the SBF apparatus and determine the airflow according to the SBF procedure. The measured flow should be .625 ± .01 1/min.
6) If the flow is not within this range, then follow the setup procedure and repeat the SBF flow measurement.
7) If variations in flow continue, then consult maintenance manual (5).
8) Remove stopper when flow adjustment is complete and set elutriator into place.



1. Handle
2. Memory power switch
3. Programme switch
4. Range switch
5. LCD readout
6. Flow control
7. Digital output socket
8. Zero control
9. Filter housing
10. Memory housing
11. Laser on/off switch
12. Averager readout
13. Function check indicators
14. Gain control
15. Averager switch
16. Analogue output socket
17. Calibration input socket

Figure 5 – SIMSLIN II control panel

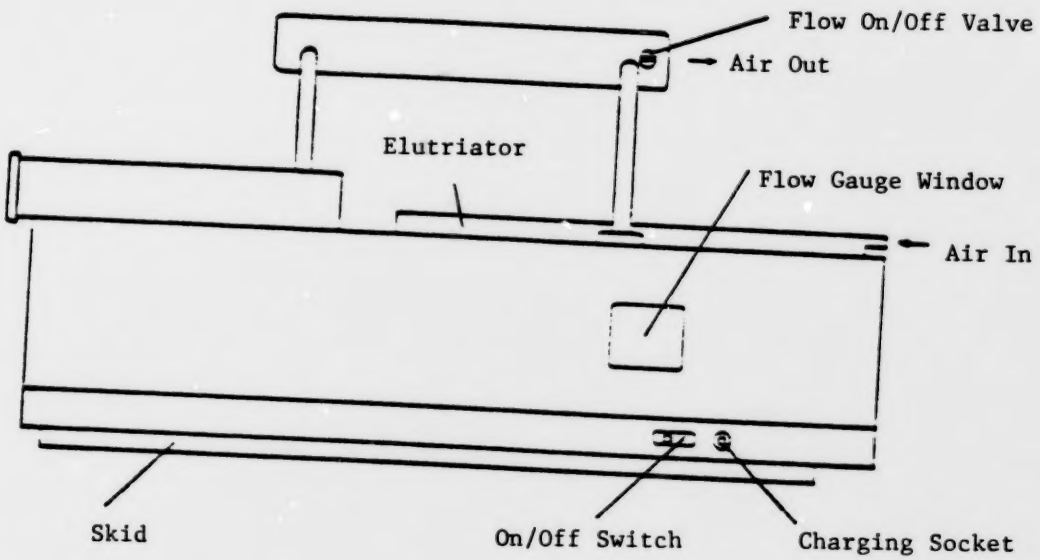


Figure 6 - SIMSLIN II continuous dust monitor

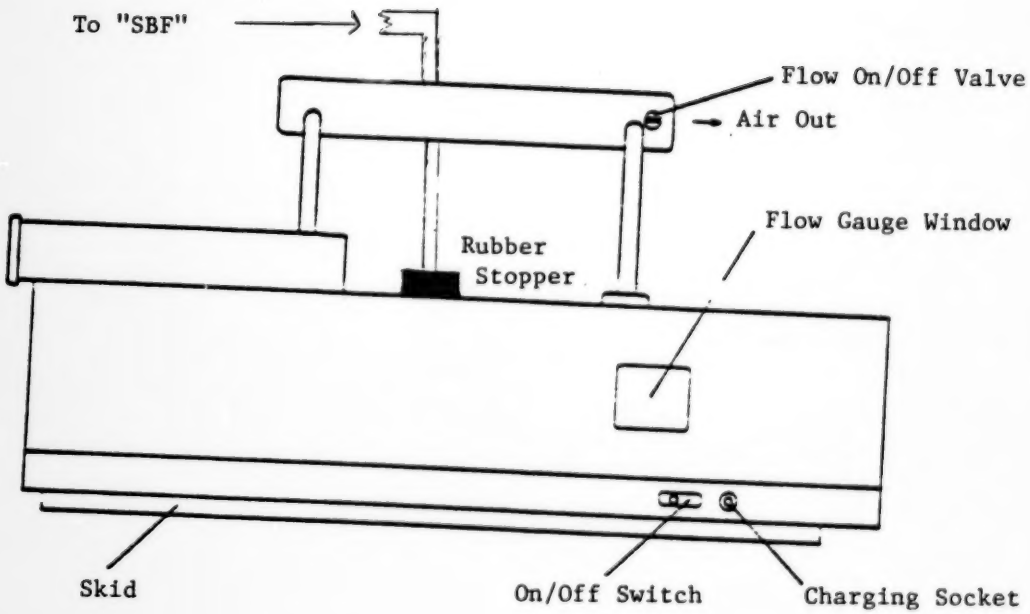


Figure 7 - SIMSLIN II flow check

DUPONT 2500A AND GILIAN HFS-113A

The DuPont and Gilian personal airflow pumps are of a modular design and consist of a self-regulating pneumatic system and an internal power pack. Each has been designed to provide a smooth airflow which can be adjusted by turning a flow control screw located on the face plate. This allows the unit to be used with a variety of sampling devices which normally require a flow range of 1.7 to 2.5 l/min.

'PERSONAL' PUMP PREPARATION AND FLOW CHECK

The following is a procedure for measuring airflows for the 'personal' pumps and the type of equipment required: a filter casette assembly containing the filter type to be used with the pump for the next test, a small length of .5 cm (ID) tubing and a SBF apparatus:

1) Clean the pump's exterior surfaces, vacuum and check internal filter for contamination, e.g. water, dirt, etc.
2) If required set up the filter casette and SBF apparatus as in Figure 2. This will provide a flow restriction in the range expected for the sampling system. If a sampler does not require a filter, then the restriction can be provided by using other devices such as a DuPont calibrator kit.
3) Turn the pump on and block off the air intake. This should result in a rapid increase in motor speed. If not then a leak is suspected in the system and corrective maintenance must be performed (2,3).
4) Measure the operating current and compare this with the specifications in the operating manual and power rating of the battery (2,3).
5) Connect the pump in series with a SBF apparatus (Figure 2) and measure the flow rate.
6) If the desired flow has not been attained, then turn the flow screw in the appropriate direction and repeat the SBF procedure.

COMMENTS

It has been our experience that irregular flows have been caused by faulty batteries, worn pistons and/or system gaskets, and on occasion water and/or dirt contaminated intake filters.

PUMP PERFORMANCE DISCUSSION

Table 3 presents some typical data of measured pump flows before and after a dust measuring period using various sampling systems. Thirty tables like these were used to create Tables 4 and 5 and from these the following discussion pertains.

COMPARISON OF PUMP FLOW VARIATIONS (USING TWO DUPONT 2500A PUMPS)

The results of Table 4 were obtained from thirty dust surveys of varying time and underground coal mine environmental conditions. It presents the difference between measured pump airflows before and after a series of surveys. These two pumps, which were used under similar conditions, were selected in order to compare a normally operating pump (No. 2) vs a pump (No. 4) which had a high occurrence of pump flow failures.

Graphs 1 and 2 (Appendix A) present plots of the differences between initial and final airflow measurements vs survey number of two DuPont pumps. Both these graphs show that the final flow measurement has an approximately equal chance of being higher or lower than the initial reading, e.g. no bias. The graphs also show that DuPont No. 4 has a greater variation in repeat airflows than No. 2. This is also shown by the standard deviation of airflow differences calculated in Table 4.

There are a number of factors responsible for this variation:

1) The type of filter and sampling unit used with the pump.
2) The location of the sampler during a dust survey resulting in varying conditions of dust concentrations and consequently different airflow restrictions through the pump.
3) Physical handling of the pump depending on whether it serves as an area or a personal sampler. A personal sampler is subjected to more physical wear and tear due to the nature of this type of sampling.
4) A defective mechanical or worn part which causes fluctuations in airflows.

Both pumps were used in similar sampling conditions during the thirty surveys. The variation in pump airflows appear to be independent in

Table 3 - Typical data presentation

Survey #1
Type- Portal to Portal
Location-Mine #1
Date-Feb 1/86
Shift-3-11

	Initial				Final					
Pump Id#	Date	Temp Deg C	B.p (kp)	Flow L/Min	Date	Temp Deg C	B.p (kp)	Flow L/Min	Filter Type	Holder #
D1	Feb 1/86	25.0	101.0	1.91	Feb 2/86	24.5	100.1	1.91	FG	D1
61	Feb 1/86	24.9	101.3	2.01	Feb 2/86	24.6	100.0	1.99	PVC	D11
03947	Feb 1/86	24.9	101.2	2.50	Feb 2/86	24.6	100.0	2.47	FG	

Comments :

Example: Pressure drop across filter in casella 3949 =1 cm h20.
Final counter read on casella 3949 = 625
Test for casella 3949 = 250 min

Table 4 - Comparison of pump flow variations

Pump Id#	Survey Date	Initial Flow L/Min	Final Flow L/Min	Delta Flow L/Min	Pump Id#	Survey Date	Initial Flow L/Min	Final Flow L/Min	Delta Flow L/Min
D2	22-Jan-85	1.88	1.89	-0.01	D4	22-Jan-85	1.90	2.03	
D2	24-Jan-85	1.89	1.88	0.01	D4	24-Jan-85	2.03	1.94	0.09
D2	29-Jan-85	1.88	1.86	0.02	D4	29-Jan-85	1.94	1.87	0.07
D2	31-Jan-85	1.86	1.89	-0.03	D4	31-Jan-85	1.93	1.90	0.03
D2	06-Feb-85	1.89	1.87	0.02	D4	06-Feb-85	1.90	1.87	0.03
D2	12-Feb-85	1.87	1.89	-0.02	D4	12-Feb-85	1.87	1.93	-0.06
D2	19-Feb-85	1.89	1.89	0.00	D4	19-Feb-85	1.93	1.90	0.03
D2	25-Feb-85	1.89	1.84	0.05	D4	25-Feb-85	1.93	1.94	-0.01
D2	07-Mar-85	1.85	1.88	-0.03	D4	07-Mar-85	1.93	1.88	0.05
D2	09-Mar-85	1.88	1.94	-0.06	D4	09-Mar-85	1.86	1.96	-0.08
D2	20-Aug-85	1.86	1.86	0.00	D4	20-Aug-85	1.89	1.89	0.00
D2	22-Aug-85	1.91	1.92	-0.01	D4	22-Aug-85	1.89	1.83	0.06
D2	24-Aug-85	1.92	1.94	-0.02	D4	24-Aug-85	1.92	1.94	-0.02
D2	27-Aug-85	1.94	1.94	0.00	D4	27-Aug-85	1.94	1.96	-0.02
D2	30-Aug-85	1.94	1.94	0.00	D4	04-Sep-85	1.93	1.90	0.03
D2	04-Sep-85	1.94	1.94	0.00	D4	05-Sep-85	1.89	1.94	-0.05
D2	05-Sep-85	1.94	1.94	0.00	D4	10-Dec-85	1.91	1.90	0.01
D2	10-Dec-85	1.88	1.86	0.02	D4	17-Dec-85	1.84	1.97	-0.13
D2	17-Dec-85	1.86	1.86	0.00	D4	14-Jan-86	1.95	1.97	-0.02
D2	14-Jan-86	1.92	1.90	0.02	D4	21-Jan-86	1.89	1.85	0.04
D2	21-Jan-86	1.89	1.89	0.00	D4	05-Feb-86	1.88	2.03	-0.15
D2	05-Feb-86	1.90	1.90	0.00	D4	11-Feb-86	1.88	1.90	-0.02
D2	11-Feb-86	1.90	1.88	0.02	D4	14-Feb-86	1.88	1.90	-0.02
D2	14-Feb-86	1.86	1.90	-0.02	D4	21-Feb-86	1.90	1.77	0.13
D2	21-Feb-86	1.90	1.91	-0.01	D4	03-Mar-86	1.91	1.94	-0.03
D2	03-Mar-86	1.89	1.88	0.01	D4	12-Mar-86	1.94	1.94	0.00
D2	12-Mar-86	1.88	1.92	-0.04	D4	14-Mar-86	1.94	1.97	-0.03
D2	14-Mar-86	1.92	1.89	0.03	D4	26-Mar-86	1.90	1.90	0.00
D2	26-Mar-86	1.90	1.90	0.00	D4	01-Apr-86	1.90	1.92	-0.02
D2	01-Apr-86	1.90	1.93	-0.03					
			STD D2 =	0.02				STD D4 =	0.06

Table 5 - A list of surveys and number of pumps used during each test. Below column 2, 3 and 4 is the percent of flow failures, "FF".

Survey #	No. Duponts 2500A per survey	No.Casellas Type 113A per survey	No.Gillian HFS-113A per survey	No.Dupont 2500A FF	No.Cassella Type 113A FF	No.Gillian HFS-113A FF
1	12	5	NA	2	1	NA
2	12	5	NA	0	1	NA
3	12	2	NA	0	1	NA
4	12	5	NA	0	1	NA
5	12	5	NA	0	1	NA
6	12	5	NA	0	1	NA
7	12	4	NA	0	1	NA
8	12	4	NA	0	0	NA
9	11	5	NA	0	1	NA
10	12	4	NA	1	1	NA
11	12	4	NA	0	0	NA
12	12	2	NA	0	0	NA
13	12	2	4	1	0	1
14	11	2	2	1	0	0
15	11	0	5	1	0	0
16	10	2	6	0	0	0
17	10	0	9	0	0	0
18	11	2	5	2	0	0
19	11	2	5	0	0	0
20	11	2	6	0	0	0
21	11	1	9	0	0	0
22	10	2	8	1	0	0
23	10	2	5	1	0	0
24	8	2	7	0	0	1
25	9	2	5	0	0	0
26	9	2	9	0	0	0
27	7	2	4	0	0	0
28	10	2	2	1	0	0
29	10	2	2	2	0	0
30	10	2	9	0	1	1
	Total	Total	Total	Total	Total	Total
	334	83	122	14	10	3

Percent of Flow Failures.

Dupont 2500A	Casella Type 113A	Gillian HFS_113A
4.2%	12.1%	2.5%

nature for the two pumps. This is indicated by Graph 3 (Appendix A) which shows that the variations are not in phase. This also suggests that the direction of the variation is independent of the conditions of measuring but depends on the individual pump.

The above information can be used in a constructive way. The graphs can indicate sudden or gradual flow variations that may alert a technician of impending flow failure in the pump. This allows time for preventive maintenance and prevents the loss of future dust measurement data. Similar graphs of all the pumping systems can be used to determine the most suitable function of a pump during each survey. For example, pumps such as D4 seem more susceptible to flow failure (even after normal maintenance) and may be used for area type sampling rather than personal type sampling. (Personal sampling tends to subject the pumps to more physical and demanding conditions.)

COMPARISON OF CUMULATIVE FLOW FAILURES OF THE DUPONT 2500A, GILIAN HFS-113A AND CASELLA TYPE 113A PUMPING SYSTEMS

Table 5 presents the number of times that flow failure has occurred during the thirty surveys of the forementioned systems. The percent flow failure recorded in Table 5 is calculated by dividing the total number of flow failures by the total number of times each of the pumps were used over the thirty surveys for that type of pump. From the table, it is shown that the percent flow failure for the DuPont 2500A is 4.2, Gilian HFS-113A is 2.5 and the Casella Type 113A is 12.1.

Graphs Nos. 4, 5 and 6 (Appendix A) represent plots of cumulative flow failure vs the number of uses of this type of pump as a group. Graphs 4, 5 and 6 can be used as indicators of expected flow failures for a particular set of pumps and/or general information concerning mechanical and electrical wear on the pumps as they are used. It should be mentioned that these graphs are only representative of the pumps used at CBCRL and also depends on the number of times the pumps were used in the dust program. The reason for presenting these graphs is to give the reader a general range of expected flow failures that may occur during a dust measuring period as carried out at CBCRL.

Both the DuPont 2500A and the Gilian HFS-113A graph show a general increase in the number of flow failures. Both graphs have early break-in

periods and few flow failures as shown by the flat section of the curve. At the 120 mark on the 'x' axis for each graph, there is a relative increase in the number of flow failures that may represent an expected projection of flow failure for this group of pumps.

The Casella Type 113A graph does not show the same trend compared to the previously discussed graphs. The graph has an immediate rise and then flattens out. This graph is not representative of a normal group of operating Casellas because the initial surveys had used two older Casella Type 113A pumps that were worn and not in good mechanical condition. The flow failures incurred with these two pumps accounted for the high flow failure rate for this type of pump during the initial surveys. In later surveys these pumps were eliminated from the program and hence the number of flow failures for the Casella Type 113A's decreased significantly.

These graphs can be used by the technician as indicators of general pump performance. For example, if the number of flow failures as indicated by the curves on the graphs begin to increase steadily then this would indicate that a more intensive maintenance program for all the pumps should be undertaken. The program would be carried out assuming that the increased flow failures were due to wear on the pump parts. This maintenance would include checking and replacing faulty batteries, system gaskets, filters and electronic parts. The results of future plots of flow failure should show the results of this maintenance by the flattening out of the curves on these graphs and indicate at a future date when the next program is to be carried out.

It is important to have a log book for recording the work done during any maintenance program. The log book or file would include dates of maintenance, the identity of the pump, the nature of the problem and the parts replaced. This will allow the technician to build up a history and profile for a group of pumps which will help in diagnosing future problems as they occur.

CONCLUSION

In order to carry out an extensive dust monitoring program that requires the use of a Casella Type 113A, SIMSLIN II, Gilian-HFS and DuPont

2500A systems and/or pumps, a flow calibration procedure as provided in this report is required.

Further investigation is required to show correlations between the temperature, barometric pressure and humidity between laboratory flow measurements and actual flows in these pumping systems in the field, e.g. underground.

The interpretation of flow results can indicate performance trends in pumping systems. From this information it may be decided what dust receptor is to be used with a pump and the type of function it may perform.

From the results observed in Table 5 concerning percent flow failure it can be seen that a certain number of flow failures can be expected with the pumping equipment being used in a dust monitoring program. This information can thus be used as an indicator of the number of dust measurements that may be lost due to flow failures in the pumping systems and can also be used to indicate how often more intensive maintenance should be undertaken.

ACKNOWLEDGEMENTS

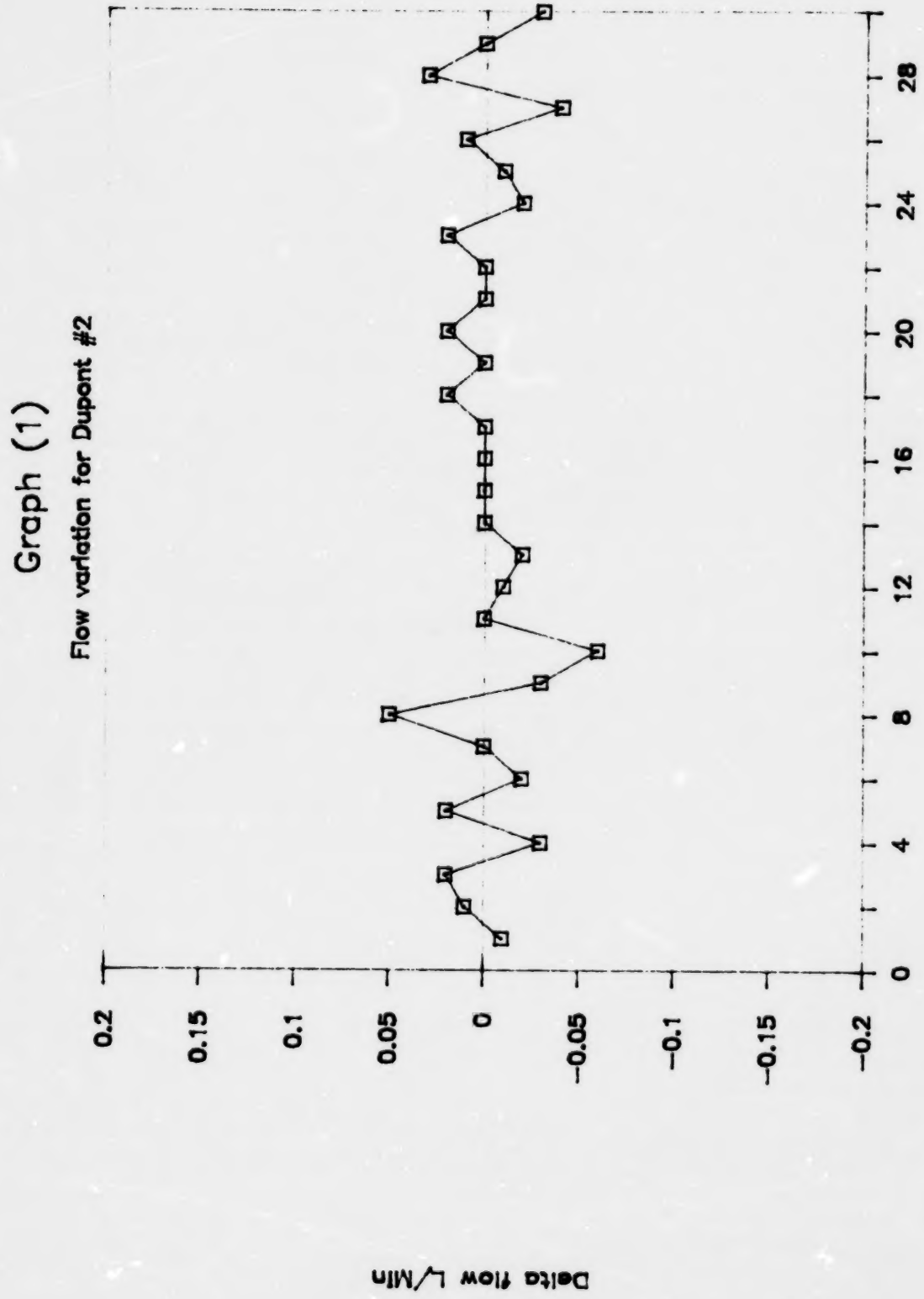
The author would like to thank Gary Bonnell of the Cape Breton Coal Research Laboratory for his assistance with this report.

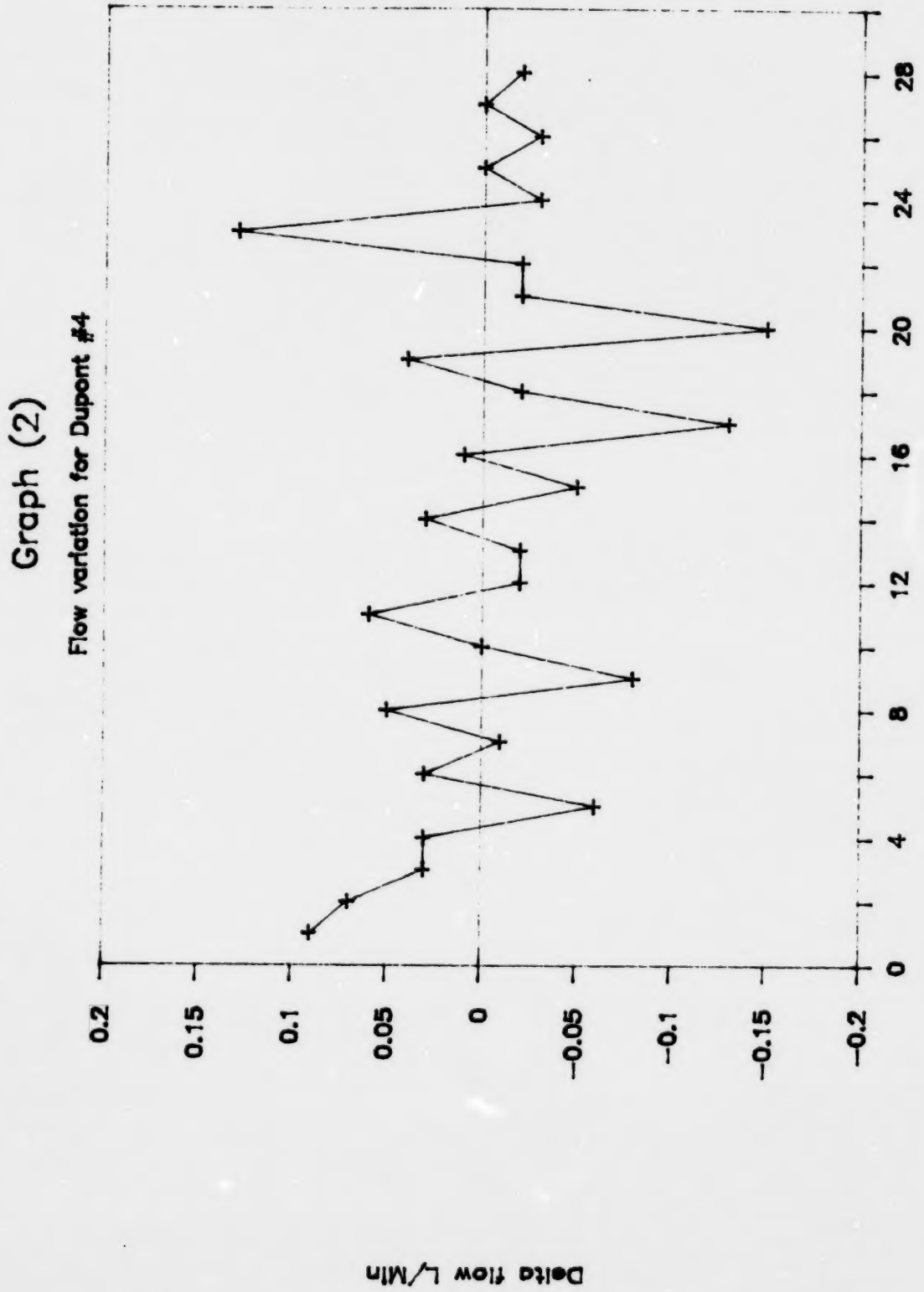
REFERENCES

1. "Gravimetric dust sampler Type 113A"; Instruction Leaflet 3104/TN; Casella London Limited; London.
2. "DuPont constant flow sampler Model-P-2500"; Operation Manual, Delaware; Copyright 1979.
3. "Gilian HFS air sampling system"; Operating Manual; Gilian Instrument Corp.; 1984.
4. Tomb, Thomas F. and Treaftis, Harry N. "Standard calibration and maintenance procedures for wet test meters and coal mine respirable dust samplers"; MESA Informational Report/1073/1978; United States Department of the Interior.

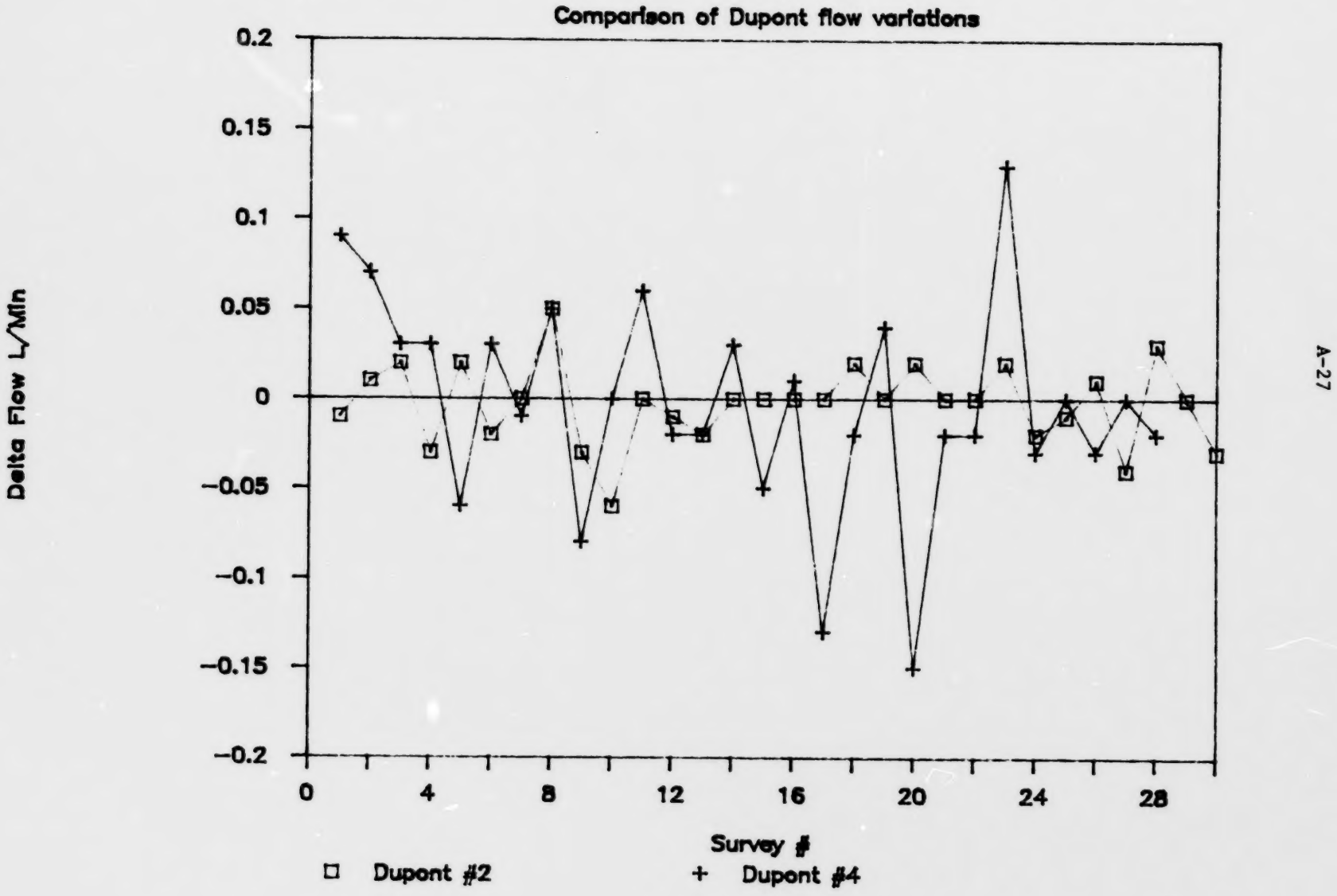
5. Rotheroe & Mitchell Ltd.; SIMSLIN II Service Manual; Second Draft 1981.
6. Corbett, G.R. 'A study of the filters used in the dust research program at the Cape Breton Coal Research Laboratory"; CANMET Division Report CRL 87-24(TR); 1987.

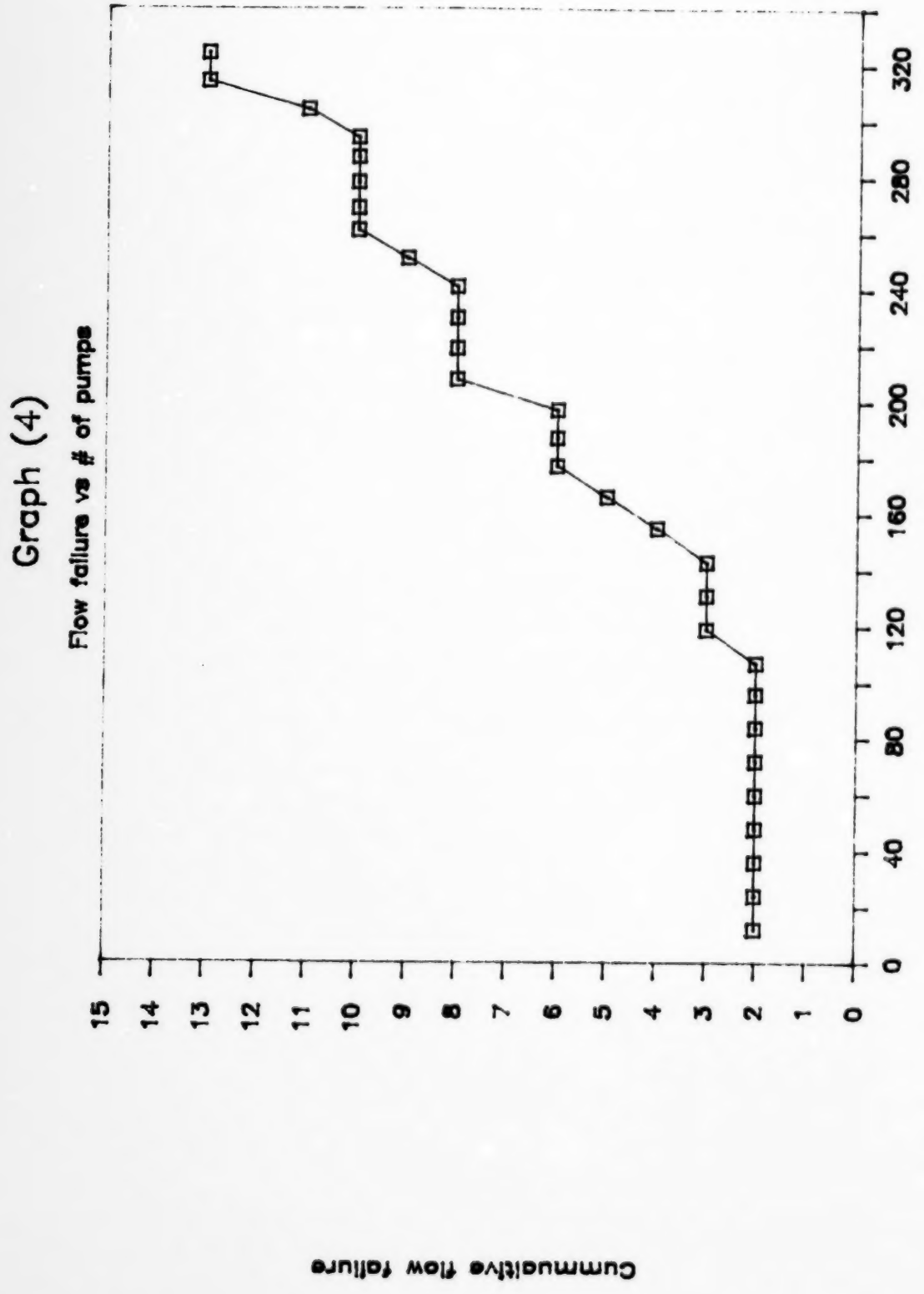
APPENDIX A


Graph (1)
Flow variation for Dupont #2
Delta flow L/Min
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0
4
8
12
16
20
24
28
Survey #
Dupont #2

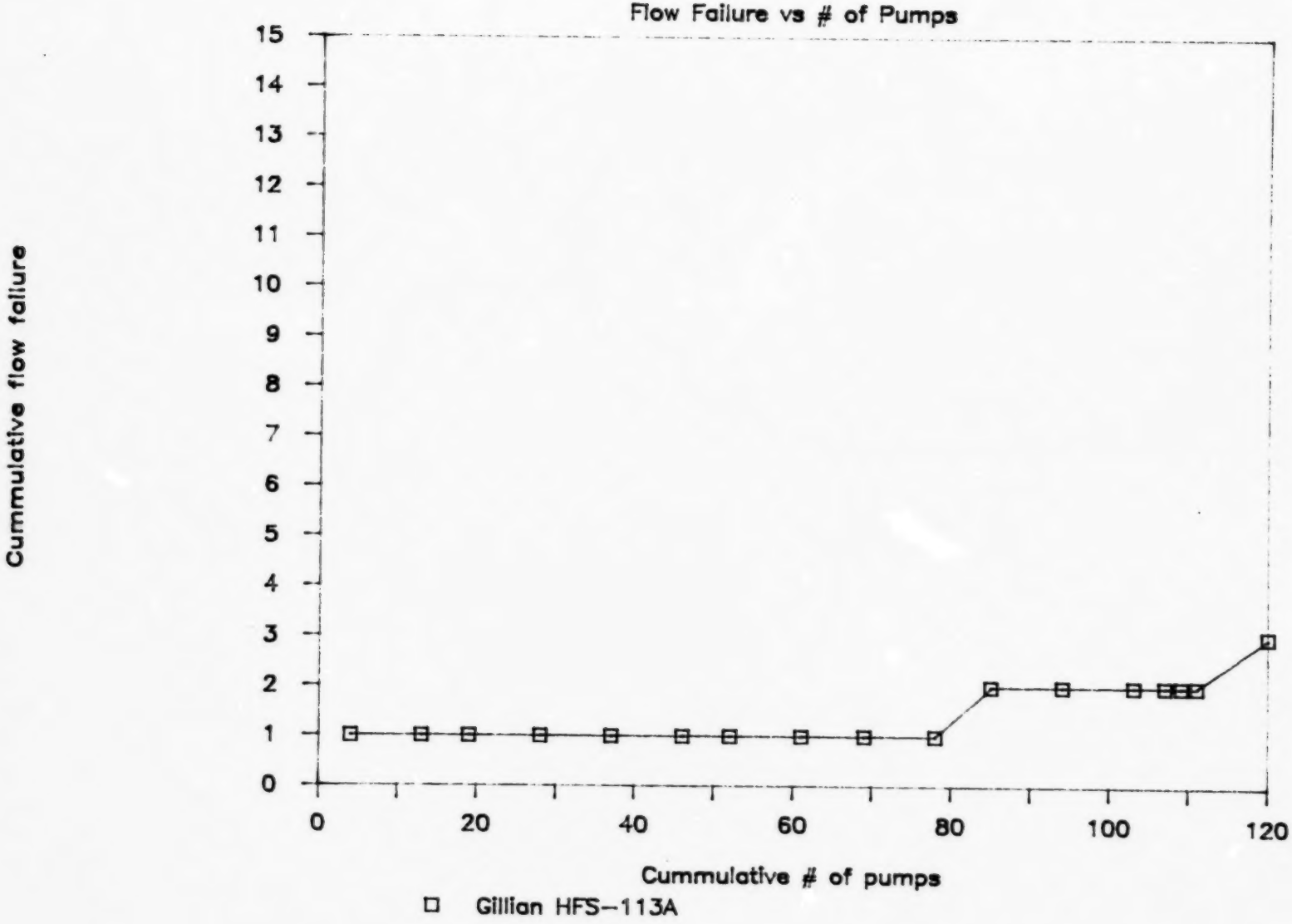

Graph (2)
Flow variation for Dupont #4
Delta flow L/Min
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0
4
8
12
16
20
24
28
Survey #
+ Dupont #4

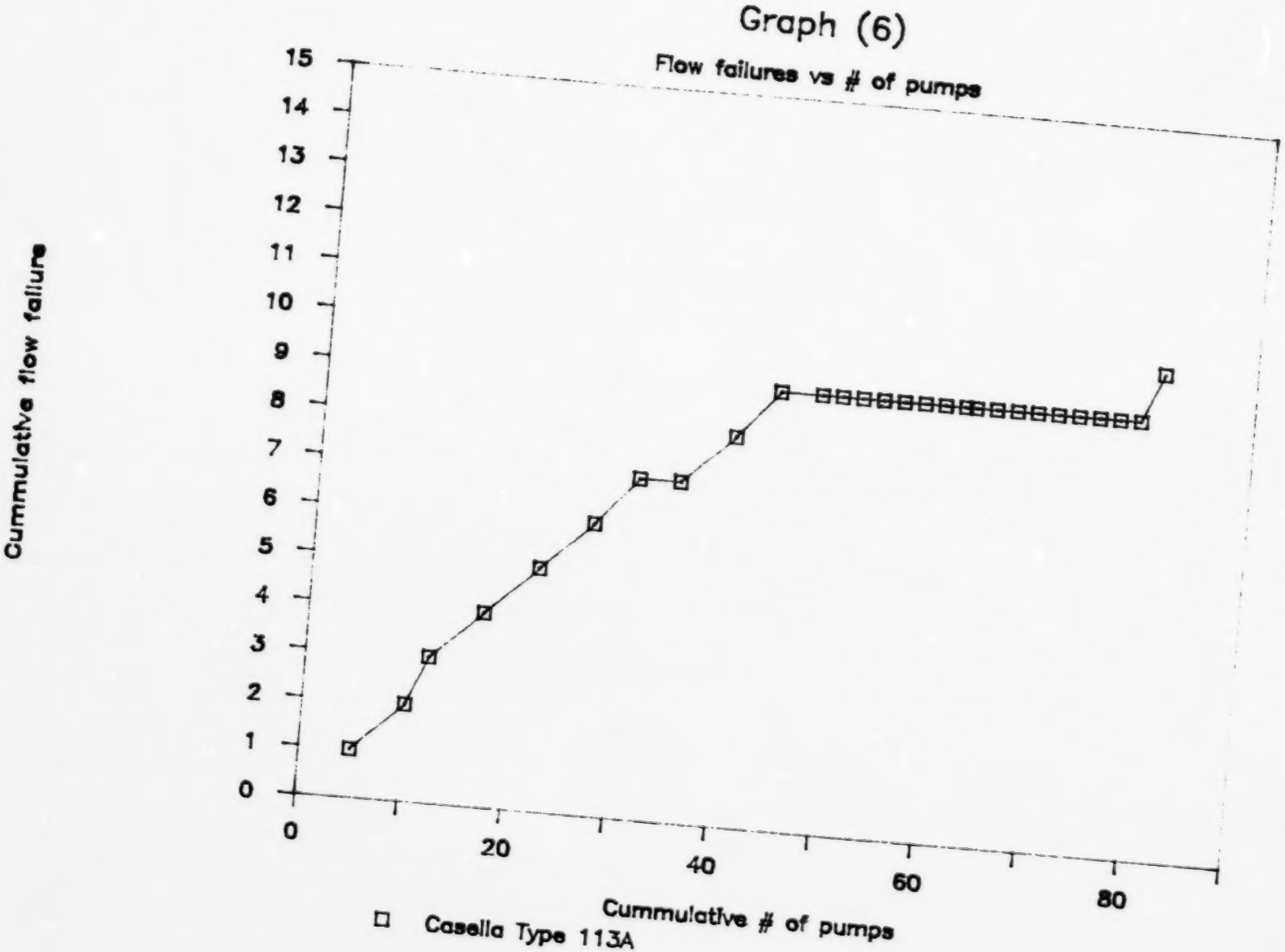
Graph (3)


Comparison of Dupont flow variations
Delta Flow L/Min
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0
4
8
12
16
20
24
28
Survey #
Dupont #2
Dupont #4


Graph (4)
Flow failure vs # of pumps
Cummulative flow failure
Cummulative # of pumps
Dupont 2500a
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
40
80
120
160
200
240
280
320

Graph (5)


Flow Failure vs # of Pumps
Cummulative flow failure
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
Cummulative # of pumps
Gillian HFS-113A


Graph (6)
Flow failures vs # of pumps
Cummulative flow failure
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
Cummulative # of pumps
Casella Type 113A